heat input required for the reverse transformation on heating, which may thereby improve the energy conversion efficiency of the system.

[0098] Heat Pipes

[0099] Heat pipes can be used to efficiently transport heat from the source to the SMA elements and/or from the SMA elements to the sink. Fixed or variable conductance heat pipes may be used to mitigate temperature drops during heat transfer between the source, SMA elements and the sink.

[0100] Vortex Tubes

[0101] Where ram air can be converted into a high static air pressure (e.g. in a moving vehicle), this high pressure air can be thermodynamically split into a cold stream and a hot stream in a vortex tube. These streams can be used to enhance the cooling and heating rates respectively.

[0102] While many approaches to a heat engine design have been outlined herein, they may each, either independently or collectively be used to improve the heat transfer rate or efficiency of a shape memory alloy heat engine or to improve its controllability. Therefore, no one approach should be considered limiting or exclusive, as many or all embodiments may be used collectively or in combination. While the best modes for carrying out the invention have been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention within the scope of the appended claims. It is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative only and not as limiting.

1. An energy harvesting system comprising:
- a heat engine;
- a driven component;
- a coupling device configured to selectively couple the driven component with the heat engine; and
- wherein the heat engine includes:
  - a first rotatable pulley;
  - a second rotatable pulley spaced from the first rotatable pulley;
  - a shape memory alloy (SMA) material disposed about a portion of the first rotatable pulley at a first radial distance and about a portion of the second rotatable pulley at a second radial distance, the first and second radial distances defining an SMA pulley ratio;
  - a timing cable disposed about a portion of the first rotatable pulley at a third radial distance and about a portion of the second rotatable pulley at a fourth radial distance, the third and fourth radial distances defining a timing pulley ratio, the timing pulley ratio being different than the SMA pulley ratio;
  - wherein the SMA material is configured to be placed in thermal communication with a hot region at a first temperature and with a cold region at a second temperature lower than the first temperature; and
  - wherein the SMA material is configured to selectively change crystallographic phase between martensite and austenite and thereby one of contract and expand in response to exposure to the first temperature and also to one of expand and contract in response to exposure to the second temperature, thereby converting a thermal energy gradient between the hot region and the cold region into mechanical energy.

2. The energy harvesting system of claim **1**, wherein the driven component is an electrical generator configured to convert rotational mechanical energy into electrical energy.

3. The energy harvesting system of claim **1**, wherein the driven component includes at least one of a fan, a clutch, a blower, a pump, and a compressor.

4. The energy harvesting system of claim **1**, further comprising a controller in communication with the coupling device and configured to control the selective coupling of the driven component with the heat engine.

5. The energy harvesting system of claim **4**, wherein the controller is configured to monitor a rotational speed of one of the first rotational pulley and second rotational pulley; and
- wherein the controller is configured to decouple the driven component from the heat engine if the monitored rotational speed is below a predetermined threshold.

6. The energy harvesting system of claim **4**, wherein the coupling device includes an adaptive torque transmitting device having a variable gear ratio.

7. The energy harvesting system of claim **6**, wherein the controller is configured to monitor a temperature of the SMA material; and
- wherein the controller is configured to modify the gear ratio of the adaptive torque transmitting device to reduce a torque load on the heat engine if the temperature of the SMA material exceeds a predetermined threshold.

8. The energy harvesting system of claim **4**, wherein the controller is configured to monitor a temperature of the hot region, and to reduce a heat source if the temperature of the hot region exceeds a predetermined threshold.

9. The energy harvesting system of claim **4**, wherein the coupling device includes a clutch.

10. The energy harvesting system of claim **4**, wherein the controller is further configured to vary at least one of the first pulley ratio and the second pulley ratio.

11. The energy harvesting system of claim **1**, wherein the driven component includes a flywheel.

12. The energy harvesting system of claim **1**, wherein the heat engine further includes an idler pulley in mechanical communication with the SMA material and disposed within the cold region.

13. An energy harvesting system comprising:
- a heat engine;
- an electrical generator;
- a coupling device configured to selectively couple the electrical generator with the heat engine;
- a controller in communication with the coupling device and configured to control the selective coupling of the electrical generator with the heat engine; and
- wherein the heat engine includes:
  - a first rotatable pulley;
  - a second rotatable pulley spaced from the first rotatable pulley;
  - a shape memory alloy (SMA) material disposed about a portion of the first rotatable pulley at a first radial distance and about a portion of the second rotatable pulley at a second radial distance, the first and second radial distances defining an SMA pulley ratio;
  - a timing cable disposed about a portion of the first rotatable pulley at a third radial distance and about a portion of the second rotatable pulley at a fourth radial distance, the third and fourth radial distances defining a timing pulley ratio, the timing pulley ratio being different than the SMA pulley ratio;